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Predicting and Optimizing Solar Cell Performance with Material/Surface Characteristics

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ABSTRACT

Renewable energy sources have begun replacing fossil fuels at the utility scale. In particular, photovoltaics has grown rapidly in recent years. To further improve solar technology in terms of cost and efficiency and promote adoption, researchers often seek material and device level advancements. Photovoltaic simulation tools can be utilized to predict device performance before fabrication and experimentation, streamline research processes, and interpret experimental results. Therefore, we developed ContourPV, which simulates various combinations of values of different device characteristics to optimize and predict photovoltaic performance. ContourPV sweeps the inputted range of values for each chosen device or layer characteristic and obtains performance data by utilizing the drift-diffusion solver, ADEPT. ContourPV plots these metrics in contour plots as output. The parameters that can be swept include Shockley-Read-Hall recombination lifetime, doping concentration, radiative recombination coefficient, and surface recombination velocity for front and rear contacts. Open circuit voltage, short circuit current, fill factor and efficiency are available as output. This tool can provide researchers with intuitive simulation results to predict the performance of a solar cell design, determine material properties based on experimental current-voltage measurements, and help predict performance crossover regions between different device designs. Silicon and GaInP are investigated as example materials in ContourPV: silicon because it is the most common material for commercial solar panels, and GaInP because it is a strong candidate for high-efficiency multijunction solar cells. Furthermore, a wide range of other material systems can be simulated in this tool by users of ADEPT.

KEYWORDS

Photovoltaics, semiconductor modeling, simulation